The Inservice Inspection and Testing Requirements and Practices in the U.S. and Other Countries

Rohini K. MATTU
Science Applications Intl. Corp. Washington Operations, USA
Soung-Nan LIU
Electric Power ResearchInstitute, Palo Alto, CA USA

ABSTRACT

Countries with operating nuclear power plants establish basic standards, known as Regulations or Orders. To comply with these standards, utilities can use in-service inspection (ISI) and in-service testing (IST) rules, criteria documents, and supplemental guidelines. These rules are generally consensus documents prepared by knowledgeable and practicing specialists in the field of inspections and testing of nuclear plant systems and components. Under contract from the Electric Power Research Institute (EPRI), Science Applications International Corporation (SAIC) compared the requirements and practices of ISI/IST of nuclear plant systems and components in different countries. Comparisons are made using the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI as standard since most countries use it as a mandatory requirement or as a basis for their guidelines for ISI/IST of their nuclear power plants.

1 INTRODUCTION

In the United States, Section XI of the Boiler and Pressure Vessel Code and the electric utility In-service Inspection and Testing (ISI/IST) programs that implement the Code requirements have traditionally responded to the lessons learned from the power plant operating experience and from the practical experience of implementing the Code requirements.

Although Section XI of the Code has set the standard for nuclear plant component ISI in many countries, these countries supplement Code requirements with requirements of their own. In addition, Code interpretations and the extent of plant compliance may vary from plant to plant and from country to country. The EPRI study attempts to compare requirements and practices in selected countries with significant nuclear energy programs and compare them with U.S. practices and Section XI Code.

The rules in each country constitute requirements to maintain the original (or sufficient) safety margins in a nuclear power plant and its components, and to return the power plant to service following plant outages in a safe and expeditious manner. The ISI/IST of plant systems including inspection of valves, critical welds, and snubbers, etc. is used not only to meet requirements but also for preventive maintenance and corrective actions, repairs and replacements. The (Ref. 3) report discusses the extent and stringency of ISI requirements, which are related to the importance that different institutions attach to the safety and operation of the systems and components to be examined and tested. It also compares acceptance standards used by these institutions for examinations and tests and corrective actions, such as repair and replacement by components considered satisfactory. Safety classes are also taken into consideration in ranking importance of systems and consequently impact the systems' ISI classification.

2 TECHNICAL DISCUSSION

The basic standards for nuclear power generation and operation in any country are the government standards, i.e., Regulations or Orders, that are prepared and published by legal bodies of the government. Since regulations have the enforcement capability, compliance is mandatory. A second category of government standards includes rules, criteria, guides, etc. that are normally published by the government organizations having direct responsibility for nuclear power plant regulation. These rules, criteria, guides, etc., require compliance only to the extent that the regulatory agency expects compliance. Alternate procedures and methods are often used with the concurrence of the regulatory agency, provided the intent of the rules, criteria, etc., is met. Table 1 shows use of Section XI and other standards by selected countries.

Section XI of the ASME B&PV Code has set the standard for in-service inspection in most countries that responded, whether it is used as a mandatory requirement or as a basis for guidelines. Twelve of the 17 countries that were surveyed for the study refer to Section XI, and 5 mandate use of Section XI or a modification of it. The IAEA Safety Guide (50-SG-02) and the IAEA (draft) ISI Manual can easily be related to the overall provisions of Section XI. Of the 15 countries responding to the question on frequency of updating of the inspection program, 8 indicated that they update more frequently than every 10 years, and 5 of those indicated that the program is updated annually or at each refueling outage.

Categorization of components for inspection requirements is quite consistently done worldwide on a basis similar to that required in Section XI. Eleven of the responses related their requirements to Section XI in the area of classification. Some countries, notably Sweden (see Table 2), use a classification system based primarily on the estimated failure risk and the importance to safety of a component as a basis for inspection classification.

Responses to additional requests for requirements and plant practices for inspection of reactor vessels (see Table 3) indicate that:

- In France the requirements for inspection of reactor vessels continues with a larger sample of reactor vessel belt-line welds than is required in Section XI. There is also a requirement for inspection of the bonding between the vessel wall and the cladding. There is no such requirement in Section XI.

- The Spanish requirement for a reactor supplied by U.S. vendors is the same as that of Section XI.

- In Japan, the sample size for inspection of welds in the vessel shell is 10% of the longitudinal welds and 5% of the circumferential welds for each interval. The same sample is used for head welds.

In Spain and the United States, the present sample size requirement includes all welds for the first interval, i.e., it is consistent with Section XI. For integrally welded attachments, the sample size in Japan is 10% of the skirt weld for each interval and 100% of lug welds for each interval.

A survey of outage time for selected countries revealed interesting results. With on-line refueling in Canadian plants, downtime is not a function of the refueling process. Outage time for Pickering Plants is four weeks each year for corrective and preventive maintenance, repair or replacement, and ISI/IST. Bruce Plants are down for 40 days

Table 1. Overview Of The Codes, Standards And Supplementary Guidance

Country	ASME Section XI	Modified ASME Section XI	Other	Mandatory	Supplementary Guidance and Comments
Belgium		X		Yes	US R.G. 1.14 and R.G. 1.83, Code Cases in R.G. 1.147 and 1.150, and 10C FR50, App. J for containment leak test.
Finland		X		-	Guidance by YWL-series guides issued by STUK.
Germany			KTA-Series	Yes	Guidelines issued by RSK (Reactor Safety C ommission).
France			RSEM	No	
India	X		N285.4	No	US Regulatory Guides (N285.4 for Candu Reactor).
Italy	X			No	US Regulatory Guides 1.150, 1.83, NUREG-1061.
Japan		JEAC-4205 ISI of Light Water Cooled Nuclear Power Plant Components		No	JEAG-4207 Ultrasonic Examination for In-service Inspection of Light Water C ooled Nuclear Power Plant C omponents and Operating experience.
Korea	X (For PWRs)		N285.4 For (Candu Reactor)	-	US Regulatory Guide 1.14, Reactor Coolant Pump Fly-wheel Integrity, Also Utility imposed Requirements.
Spain	X		KTA-Series	No	US Regulatory Guides, Standard Review Plans, and Guidelines issued by RSK (Germany).
Sweden	X		SKI-FTKA	Yes	10CFR50, APP. A, US Regulatory Guides, IEEE Stds., and the Swedish 30-minute Rule.
Switzerland			SVBD NE-14	Yes	
Taiwan	X		Plant Tech. Specs.	Yes	US Regulatory Guides.
USA	X		App. J, 10CFR50, Plant Tech. Specs. ASME Code Sections III, V, IX.	Yes	US Regulatory Guide 1.14, 1.83, 1.150, etc., ASME Code Cases listed in R.G. 1.147. ANSI/ASME O&M Standard for Functional Testing, NUREG Reports, INPO and EPRI Publications.

Table 2. Categorization Of Components For ISI

Country	Categorization	Bases for Categorization	Selection of Components Within Categories
Japan	Similar to ASME Section XI, Class 1, 2, & 3.	Similar to ASME Section XI, Class 1, 2, & 3.	JEAC 4205; operating experience, even distribution of inspection points; accessibility; whether or not a component is representative.
Spain	ASME Section XI.	ASME Section XI.	Sample percentage as in ASME Section XI.
Sweden	Control Group A, B, C, except Reactor Vessel which is subject to ASME Section XI requirements	The bases for categorization are in R.G. 1.26. (maintain integrity of reactor fuel, prevent LOCA, etc.)	Selection of inspection items is based on (1) Design and (2) Service, i.e. for (1), choice of matl. and geometrical discontinuities, and for (2), basis is stress level, temperature, vibration, corrosion, and erosion of material. Inspection items are selected to represent severe Design and Service Factors. C lass 1 and 2 piping and components (including Pressure Vessel) are designed and installed in a way that takes into consideration accessibility demands and inspection methods.
Switzerland	Similar to ASME, Section XI, includes Class 4.	Similar to ASME, Section XI.	Selection of systems/components for inspection or testing is based on evaluation of stress, corrosion, erosion, results of previous inspections and tests, and experience of similar operating plants.
USA	ASME Section XI requirements.	R.G. 1.26 and ASME Section XI.	ASME Section XI.

Table 3. Requirements For Inspection Of Reactor Pressure Vessels For Selected Countries

	JAPAN	FRANCE	SPAIN	USA
AREA	SHELL WELDS IN CORE REGION (BELTLINE)			
METHOD	Volumetric	UT UW	UT	UT
SAMPLE SIZE	Long. Circum.			
1st INTERVAL	10% 5%	-	All Welds	All Welds
1st Period	10 - 40%	-	33% or 0	0
2nd Period	50 - 70%	-	33% 0	0
3rd Period	100%	100%	34% 100%	100%
SUBSEQUENT INTERVALS	10% 5%		One Weld	One Weld
1st Period	10 - 40%	-	33% or 0	0
2nd Period	50 - 70%	-	33% 0	0
3rd Period	100%	100%	34% 100%	100%
AREA	HEAD WELDS, CIRCUMFERENTIAL (GIRTH) AND MERIDIONAL			
METHOD	Volumetric	UT UW	UT	UT
SAMPLE SIZE	Long. Circum.			
1st INTERVAL	10% 5%	All Welds	All Welds	All Welds
1st Period	10 - 40%	-	33% 0*	33%
2nd Period	50 - 70%	-	33% 0	33%
3rd Period	100%	100%	34% 100%	34%
SUBSEQUENT INTERVALS	10% 5%	All Welds	One Weld	One Weld
1st Period	10 - 40%	-	33% 0*	33%
2nd Period	50 - 70%	-	33% 0	33%
3rd Period	100%	100%	34% 100%	34%
			* BOTTOM HEAD ONLY	
AREA	PIPE WELD TO VESSEL NOZZLES, NOZZLE TO SAFE-END			
METHOD	Volumetric & Visual Safe-end Pipe	UT UW, RT	UT & Surface	UT
SAMPLE SIZE	All 25%			
1st INTERVAL	All	-	All	All
1st Period	100% 100%	-	min 25% max 50% or 33%	33%
2nd Period	100% 100%	-	0 3	33%
3rd Period	100% 100%	100%	100% 34%	34%
SUBSEQUENT INTERVALS	All 25%	-	All	All
1st Period	100% 100%	-	min 25% max 50% or 33%	33%
2nd Period	100% 100%	-	0 33%	33%
3rd Period	100% 100%	100%	100% 34%	34%

every 2.0 to 2.5 years for similar activities. All other sources (U.S., Spain, Japan, and France) indicated that refueling outages are used for maintenance, repair, replacement, and ISI/IST activities (see Table 4). The French average outage time for a plant is 30 to 40 days each year, always between April and November. Spanish plants have an objective of a 30-day outage for each plant following 12 months of operation. The Spanish are at present averaging 40 days for annual outage, and the history shows that they have brought the average outage time down to 40 days from about 3 months. The Japanese data show a strong progression toward reduced outage time and a reduced frequency. Originally, outages occurred once a year and could last up to 6 months. The present average for outage is about 2 months following 12 months of operation. U.S. plants' operating time is 12 to 15 months between outages. No clear relationship could be observed among length of outage time, frequency of outages, and age of the plant.

Table 4. Plant Outage In Selected Countries

COUNTRY	AVERAGE OUTAGE TIME	REFUELING	MAINTENANCE	REPAIRS & REPLACEMENTS	ISI/IST
USA	Average 60-90 days	X	In-service Survail. Valve Improvement. Preventive Maintenance.	Misc. Repairs Plant Modification	Piping, ISI, Snubbers, Test Valves
FRANCE	Average for Annual outage is 30-40 days. Major/10 year outage for longer period.	X	Planned Preventive & Corrective Maintenance	Planned Modifications (Repair & Replacement)	VariousInspections, Pipe welds, snubbers, System checks, etc.
JAPAN	2 to 3 months outage following 12 months of operation	X	X	X	X
SPAIN	30 to 40 days following 12 months of operation	X	X	X	ISI/IST activities also include ISI/IST of Turbine Heat Exch. tubes, secondary side E/C, Bolts inspection ,etc.

There are few differences between countries on extent of examinations, with most requirements being very similar to those of Section XI. India does not have a requirement for examination of Class 2 systems, but no information on plant practice was available. Belgium has more rigid requirements than the United States on inspection of steam generator tubing. Section XI does not address this item, which can be plant specific.

Personnel training and certification in 8 of the 17 countries that responded is performed to the American Society for Nondestructive Testing (ASNT) standards or similar standards. Other countries have established government or testing society standards.

The extent of in-service inspections and examinations is a function of the importance of systems and components, with pressure-retaining components in reactor coolant systems (RCS) treated as more important to safety than components connected to the RCS essential for ensuring the safe shutdown of the reactor. Components are examined by visual, surface, and volumetric methods, and in addition, the integrity of pressure-retaining components is checked by in-service testing (IST) to assure acceptable leakage.

A system leakage test is conducted as part of the preservice examination. To assure the integrity of the reactor coolant pressure boundary (RCPB), a system hydrostatic pressure test is generally conducted at or near the end of each inspection interval, following each reactor outage and before resuming operation.

CONCLUSIONS

The comparisons indicate that for a large number of LWR plants the ASME B&PV Section XI Code and ISI/IST programs that implement the Code requirements have traditionally responded to the lessons learned from operating experience and also have benefited from the practical experience of implementing the requirements. A review of various Standards, Code activities, utility ISI/IST programs and inspection results, and regulatory activities shows a continuing expansion of the scope of ISI/IST programs and corresponding changes in the Section XI Code.

Key developments include:

- Enhanced training and qualification of nondestructive examination (NDE) personnel and performance demonstration for ultrasonic examination systems.

  This involves addition of the new Mandatory Appendix VII (Qualification of Nondestructive Examination Personnel for Ultrasonic Examination) and Appendix VIII (performance Demonstration for Ultrasonic Examination Systems) into the Section XI Code.
- Testing of all pumps and valves that perform a safety-related function, regardless of construction code.

  New standards, OM-6 for In-service Testing of Pumps and OM-10 for In-service Testing of Valves provide significant changes in the in-service testing requirements of pumps (IWP of Section XI) and valves (IWV of Section XI). The new rules for testing pumps and valves incorporate lessons learned over the years by the power plant operators while using IWP and IWV of the Code.

- Inspection of some balance-of-plant (BOP) systems.

  BOP systems are getting attention because non safety-related portions of the secondary coolant systems do not have established inspection programs.

REFERENCES

ASME. Boiler and Pressure Vessel Code, Section XI.

Code of Federal Regulations. Title 10, Section 50.55 (10 CFR 50.55).

Mattu, R.K., et. al., EPRI NP-5919